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Analyses of Energy use and CO₂ Emission in Residential Sector: Case Studies in Thailand and Vietnam

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Abstract

This paper presents the energy consumption and CO₂ emissions in the residential sector for both Thailand and Vietnam. The Long-range Energy Alternatives Planning (LEAP) model is employed for analysis of energy consumption and CO₂ emissions under three scenarios. The business-as-usual (BAU) scenario, which represents the residential sector without any climate policy intervention. The energy system in the base year 2010 is modeled using the secondary data and then existing energy consumption trends will be projected to the end of the planning period, that is 2030. The demand side management (DSM) scenario focussed on the efficiency improvement of four electric appliances: lighting, air-conditioners, cooking, and refrigerators to reduce the energy intensity in the residential sector. In the renewable energy (RE) scenario, the renewable energy utilization is used to analyze the energy consumption and CO₂ emissions in the residential sector in both countries. Results are compared for both countries to find out which scenario is suitable for energy savings and CO₂ emission reduction.

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Keywords: Residential sector, CO₂ emission, Energy use, LEAP model, Thailand and Vietnam

1. Introduction

With the recent rapid development of population and economic, the issue of energy demand and CO₂ emissions has become an area of intense research. In the report of “World Energy outlook 2010” [1]

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published by IEA, it was clearly highlighted that how important the modern energy to achieve each of the Millennium Development Goals. Especially in the residential sector, improvements in living standards have caused a high growth of household related CO₂ emission. To cope with this issue, it is necessary to set CO₂ reduction targets and promote efficiency.

1.1. Thailand Residential Sector

In Thailand total energy consumption in the residential sector was about 11,040 ktoe in 2011, which was accounted for 15.6% of the final energy consumption [2]. Out of three demographic divisions, rural households consumed 8,467 ktoe, which was accounted for 76.7% of final energy consumption in this sector. The remainder was shared by the greater Bangkok area and the municipal area, which were accounted for 14.1% and 9.2%, respectively. Change in energy consumption by fuel type in the residential sector from 1995-2011 is given in Figure 1 [3]. Similar to the previous years, in 2011 traditional renewable energy (fuel wood, charcoal and paddy husk) was the major share in the fuel mix. It was accounted for about 56% share in total consumption followed by electricity at 25.4% share and petroleum products, mainly LPG, at 18.3% share.

1.2. Vietnam Residential Sector

Total energy consumption in the residential sector was reported as 16,051 ktoe in 2010, which was accounted for 32.9% of the final energy consumption in Vietnam [4]. The most energy efficient households are in the dwellings and large households. The least efficient ones are in small households. They are air conditioners [5]. All the households, covered by the survey, mainly use electricity for lighting and at least one electric fan. There are around 130 million lamps installed in homes in Vietnam; 60 million of these are compact fluorescent lamps (CELs) and 54 million are fluorescent tubes. Most of the rest is incandescent bulbs (16 million) [6]. Most of the electricity consumption in the residential sector is represented by five end use devices: lighting, air conditioning, rice cookers, refrigerator, and television.

2. Methodology

The flow diagram of the LEAP model is shown in Figure 1. Three scenarios are modeled by taking 2010 as the base year and projected the future energy demand within the time horizon of 2010-2030 for both Thailand and Vietnam. Results will be presented by changes in energy demand, in the fuel mix and in CO₂ emissions.

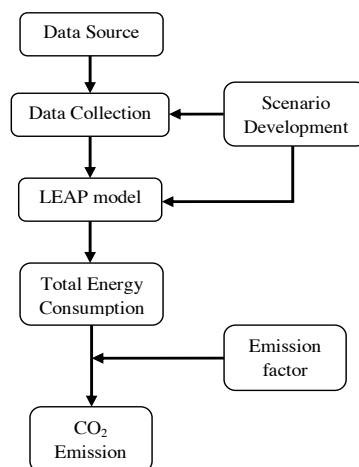


Fig. 1. Flow diagram of LEAP model

2.1. Long-range Energy Alternatives Planning (LEAP) model

The Long-range Energy Alternatives Planning System (LEAP) model has been developed by the Stockholm Environmental Institute (SEI) to analyze energy policy and climate change. The main concept of LEAP is an end-use driven scenario analysis. Moreover, the model contains the technology and environmental data based (TED) that was used to estimate the environmental emissions from the energy utilization.

The data for the LEAP model include the base year and any of the future years. By using the function such as extrapolation and interpolation or growth rate method, the energy demand and environmental emission can be estimated for the toward years. In this study, carbon dioxide emission is considered by using the emission factors based on values that recommended by the Intergovernmental Panel on Climate Change. [7]

3. Results

The results are presented in two parts: electricity demand and CO₂ emissions in three scenarios: BAU scenario, demand side management (DSM) scenario, and promotion of renewable energy (RE) scenario.

3.1. Business as Usual (BAU) Scenario

Table 1 provides the demographic data of Thailand and Vietnam in 2010. The electricity demand is expected to increase from 11,000 ktoe in the base year to 15,600 ktoe in 2030 for Thailand and from 16,118 ktoe in 2010 to 18,660 ktoe in 2030 for Vietnam. Comparison of fuel mix between Vietnam and Thailand is shown in Figure 1.

Table 1: Demographic data of Thailand and Vietnam in 2010

| Country | Thailand | | Vietnam | |
|------------------------------|-----------|-------|-----------|-------|
| | Municipal | Rural | Municipal | Rural |
| Population (millions) | 30.3 | 36.1 | 27.8 | 59.1 |
| Population (%) | 45.7 | 54.3 | 32 | 68 |
| No. of households (millions) | 7.2 | 8.6 | 6.6 | 14.1 |

It can be seen that the energy demand will be fulfilled by using coal, oil, biomass, and electricity in both Vietnam and in Thailand. Fuel mix includes biogas, charcoal, kerosene and LPG.

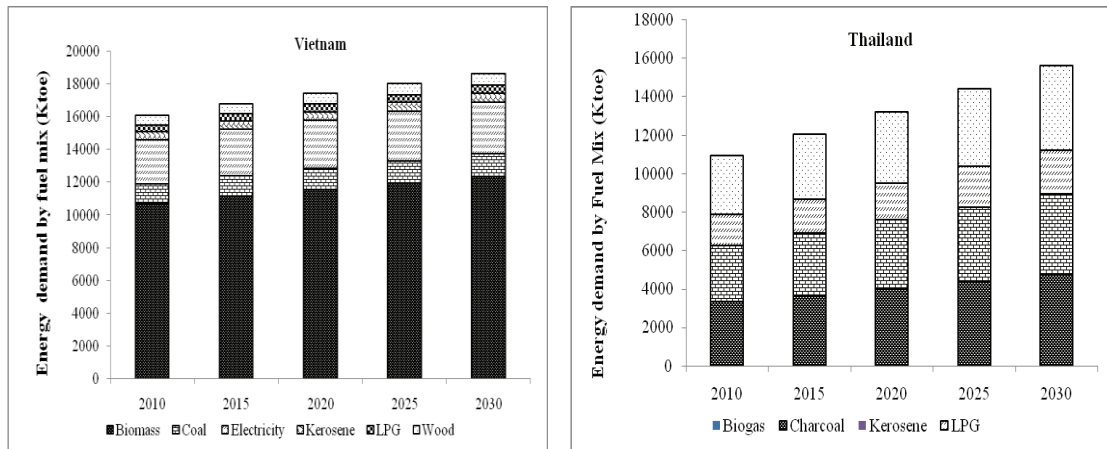


Fig. 2. Comparison of fuel mix between Vietnam and Thailand

The CO₂ emission factors are shown in Table 2 [8], [9]. The expected emission level is calculated by multiplying the forecasted amount of fuel demand by the corresponding emission factors.

Table 2. Emission factor by fuel type

| Fuel | Emission factor (Ton CO ₂ /toe) | Fuel | Emission factor (Ton CO ₂ /toe) |
|-------------|---|----------|---|
| Biogas | 2.31 | Kerosene | 3.04 |
| Biomass | 4.22 | LPG | 2.67 |
| Wood | 4.73 | Charcoal | 4.73 |
| Electricity | 6.78 | Oil | 3.06 |

The total CO₂ emissions from the residential sector has increased gradually during the study period. Total CO₂ emissions in Vietnam's residential sector are more than Thailand during the same period. When emissions from biomass is included, total CO₂ emissions in the BAU scenario will increase from 54.6 million tons in 2010 to 77.8 million tons in 2030 in Thailand's residential sector and in Vietnam it will increase from 74.66 million tons in 2010 to 86.47 million tons in 2030.

When CO₂ emission from biomass consumption is not considered, total CO₂ emission in Vietnam will increase from 26.67 million tons in 2010 to 30.96 million tons in 2030. Total CO₂ emission in Thailand's residential sector will increase from 40.6 million tons in 2010 to 57.1 million tons in 2030. Figure 2 shows the comparison of CO₂ emission between Vietnam and Thailand.

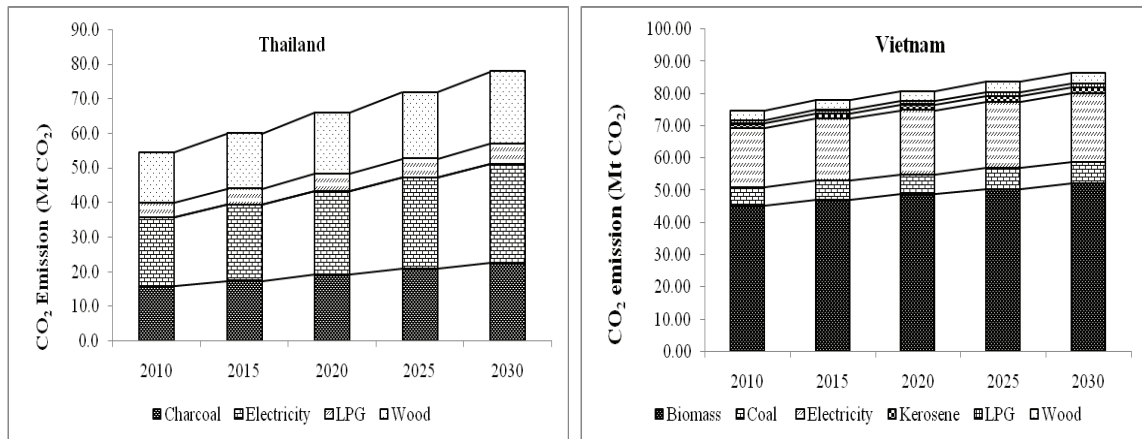


Fig. 3. Comparison of CO₂ emissions between Vietnam and Thailand in the BAU.

3.2. DSM and RE scenarios

In 2030, energy demand in Vietnam can be saved by 3,359 ktoe in the DSM scenario, and only 2,426 ktoe can be saved in the RE scenario. For Thailand, energy demand can be saved by 600 ktoe in the DSM scenario, and only 1,500 ktoe can be saved in the RE scenario.

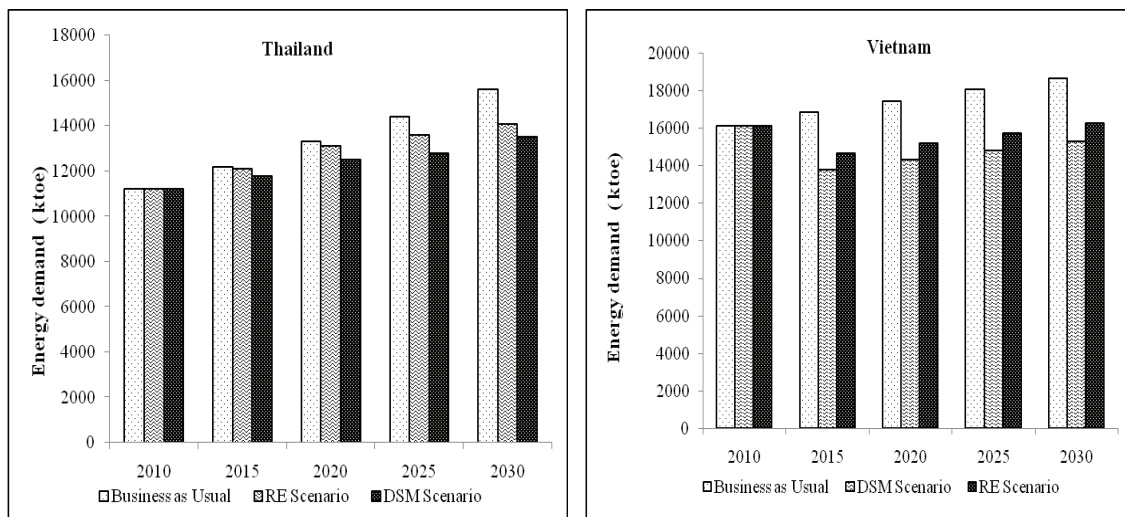


Fig. 4. Comparison of energy demand between Vietnam and Thailand in all scenarios

Both DSM and RE scenarios will help not only reduction of energy consumption in the residential sector but also mitigation of CO₂ emissions that cause the global warming. In the DSM scenario, CO₂ emissions in Thailand will increase to 62.2 million tons in 2030 (accounted for 14% reduction from the BAU in 2030) and CO₂ emissions in Vietnam will increase to 79.12 million tons in 2030 (accounted for 6.7% reduction from the BAU in 2030). In the RE scenario, CO₂ emissions in Thailand will be decreased

by 4.7 million tons from the BAU in 2030, and CO₂ emissions in Vietnam will be decreased by 3.25 million tons from the BAU in 2030. CO₂ emissions in all scenarios are shown in Table 3.

Table 3: CO₂ emissions in all scenarios for Thailand and Vietnam (Million tons CO₂)

| Scenario | Thailand | | Vietnam | |
|--------------------------|----------|------|---------|-------|
| | 2010 | 2030 | 2010 | 2030 |
| Business as Usual | 54.6 | 77.8 | 74.66 | 84.78 |
| DSM Scenario | 54.6 | 62.2 | 74.66 | 79.12 |
| RE Scenario | 54.6 | 73.1 | 74.66 | 81.53 |

4. Conclusion

Energy consumptions in the residential sector in Thailand and Vietnam were modeled by using the LEAP model. Three scenarios are included in this study: the business as usual (BAU) scenario, the demand side management (DSM) scenario, and the renewable energy (RE) scenario. Results of analyses show that in the BAU scenario energy demand in households in 2030 will reach 15,600 ktOE in Thailand and 18,660.4 ktOE in Vietnam. Results also show an energy demand reduction for both countries in all scenarios. CO₂ emissions in Thai households will reach 62.2 million tons in the DSM scenario in 2030 and 73.1 million tons in the RE scenario in 2030. In addition, CO₂ emissions in Vietnamese households will reach 79.12 million tons in the DSM scenario in 2030 and 81.53 million tons in the RE scenario in 2030.

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